Research Article

Journal of Plantation Crops, 2015, 43(2):126-130

Growth and yield of new generation clones of *Hevea* under the agroclimate of sub-Himalayan West Bengal

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(Manuscript Received:29-07-14, Revised:12-01-15, Accepted:22-05-15)

Abstract

Five rubber (*Hevea brasiliensis*) clones of the RRII 400 series derived from a cross involving RRII 105 and RRIC 100, along with five other popular clones *viz.* PB 217, RRII 176, RRII 203, RRII 105 and RRIM 600, were evaluated in Jalpaiguri district of sub-Himalayan West Bengal. Growth of clones in the immature and mature phases, rubber yield over seven years of tapping, biomass and timber yield were recorded for assessing the suitability of clones to the region. Clones RRII 429, RRII 417 and RRII 203 were superior in performance in the region compared to the recommended clone RRIM 600. Estimates of genetic parameters revealed comparatively high heritability and scope for improvement of rubber yield by selection.

Keywords: Heritability, *Hevea*, RRII 400 series clones, stability, yield improvement

Introduction

Hevea, though a native of the rainfed tropical Brazil, is adaptable to sub-optimal areas of many Asian countries. The Indian climate is very diverse with well defined climatic zones *viz.* tropical rain, tropical wet and dry, sub-tropical rain, temperate and desert (Priyadarshan *et al.*, 2005). Such variable climate, combined with different latitude, longitude and altitude has made the land more challenging for rubber cultivation in India. The southern-most part of peninsular India, mainly the state of Kerala and Kanyakumari district of Tamil Nadu are ideally suited for rubber cultivation which is considered as the traditional rubber growing area in India. However, different regions of north eastern part of India, though cold prone, were also found to be partially suitable for cultivation (Sethuraj *et al.*, 1989; Rao *et al.*, 1993) even though variations in growth and yield have been observed in different agro climatic regions. The Jalpaiguri district of sub-Himalayan West Bengal (26º43′ N latitude; 88º26′ E longitude and altitude 69 m above MSL) within northeast India is one of the non-traditional rubber growing areas. This region experiences severe low winter temperature (below 8 ºC) with heavy rainfall (Annual mean 3699 mm). Due to fluctuation of weather events every year and also within a year, long term evaluation is required for identifying the superior *Hevea* clones suitable for the region. Hence, a set of 10 clones including modern RRII 400 series clones were evaluated for their growth and yield potential in this region.

Materials and methods

The trial was initiated in 1996 in the Regional Experiment Station of Rubber Research Institute of India, Nagrakata, Jalpaiguri, West Bengal. Five clones of *Hevea brasiliensis* derived from a cross involving RRII 105 and RRIC 100 along with five other clones *viz.* PB 217, RRII 176, RRII 203, RRII 105 and RRIM 600, were evaluated in randomized block design with three replications and sixteen trees per plot. The trees were planted in 5 x 5 m square spacing. All the cultural practices were

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followed as per the recommendations of Rubber Board. Girth of the plants at 150 cm height was recorded annually from third year of planting and the data was used to calculate girth increment rates during immature phase (from 3rd to 7th year) and mature phase (from 8th to 13th year). Biomass was estimated at 16th year of growth, following Shorrocks *et al.* (1965) and timber yield in terms of clear bole volume (CBV) was computed based on girth and first branch height following true volume method (Chaturvedi and Khanna, 1982). Trees were opened for harvesting latex in the seventh year after planting following S/2 d3 6d/7 system of tapping (*i.e.* two tappings per week once in three days). Dry rubber content (drc) was expressed on percentage basis by coagulating 10 g of latex into sheet and then drying it in an oven at 80 ºC. Data on dry rubber content from each clone were taken on monthly basis. Yield was recorded on sheet weight basis from each tree twice in a month. Pre-winter yield contribution (from October to December) was calculated from the monthly yield.

Analysis of variance was carried out for all the parameters. Yield improvement over RRIM 600 (check clone) was calculated on percentage basis. Genotypic and phenotypic variance and broad sense heritability on seasonal basis was calculated from the linear function of MS (Abd El-Salam *et al.*, 2010). Ranking of clones for high yield and stability for yield was done following Kang (1993).

Results and discussion

Clonal variations were observed for all the parameters studied. Significantly high girth at the time of panel opening for harvesting latex was observed in RRII 429 and RRII 203 compared to RRIM 600; however, by 16th year, girth of all the clones were either at par or inferior to the check clone. During the immature phase, girth increment of RRII 429, RRII 417 and RRII 422 was superior to RRIM 600, while during the mature phase, girth increment of RRII 105 was superior to the check clone (Table 1). Girth increment of RRII 429 during the immature phase was found to be highest in Tripura (Deepthy *et al.*, 2010). RRII 429 recorded the highest biomass of 348 kg tree^{-1}, though clonal variations were not significant. Meti *et al.* (2003) observed better mean biomass increment for RRII 429 and RRII 203 during the early growth phase itself. High biomass accumulation and carbon sequestration potential of RRII 429 has been reported from the traditional rubber growing area as well (Ambily *et al.*, 2012).

Vigorous and fast growth rate of trees in addition to attaining early tappability have a definite advantage on wood volume also. Clear bole volume of RRI 203 and RRII 176 was significantly higher than the check clone, RRIM 600. The bole volume of RRII 429, RRII 417 and RRII 422 was on par with the control. Compared to RRII 105 in the traditional rubber growing region, high clear bole

Table 1. Growth characteristics of the clones

Clones	Girth atopening (cm tree^{-1})	Girth at16th year (cm tree^{-1})	Girth increment		Clear bole volume (m^3 tree^{-1})	Biomass (kg tree^{-1})
			Immature phase (cm tree^{-1}yr^{-1})	Mature phase (cm tree^{-1}yr^{-1})		
RRII 414	46.5	59.2	0.3	3.42	0.06	223
RRII 417	49.1	63.7	0.5 **	2.87	0.08	273
RRII 422	42.0	66.9	0.4 *	4.43	0.07	314
RRII 429	54.1 **	69.4	0.5 **	0.68	0.08	348
RRII 430	43.4	58.3	0.3	3.77	0.06	214
PB 217	46.8	66.5	0.3	3.57	0.08	308
RRII 203	50.2 *	68.2	0.3	1.35	0.09 *	333
RRII 105	43.0	59.4	0.3	5.16 *	0.06	225
RRII 176	42.7	69.0	0.3	4.13	0.09 *	341
RRIM 600	41.8	65.5	0.3	3.43	0.08	295
CD (P≥0.05)	7.6	NS	0.1	1.45	0.01	NS

* Significant at 5 per cent level ** Significant at 1 per cent level

Table 2. Mean yield and yield related parameters in different clones (gram tree^{-1} tap^{-1})

Clones	Mean yield (g tree^{-1} tap^{-1})			Pre-winter contribution over 9 years (%)	DRC (%)
	BO-1 panel Over 5 years	BO-2 panel Over 4 years	Over 9 years		
RRII 414	23.4	47.0	35.9	48.5	31.1
RRII 417	39.6	66.2 *	54.3	52.4	33.1 *
RRII 422	35.8	65.1 *	51.2	47.7	32.0
RRII 429	48.2 **	71.9 *	61.1 *	45.1	31.4
RRII 430	32.0	61.6	47.4	52.0	33.0
PB 217	24.8	42.7	33.0	47.9	30.1
RRII 203	29.3	42.2	35.3	47.8	30.7
RRII105	29.7	54.2	42.3	53.4	31.9
RRII176	22.8	40.5	32.0	43.3	30.4
RRIM 600	27.6	44.6	38.5	48.0	30.8
CD (P≥0.05)	14.7	20.2	16.2	NS	1.6

* Significant at 5 per cent level. ** Significant at 1 per cent level.

volume for all the RRII 400 series was reported (Meenakumari *et al.*, 2013). The data on mean yield in BO-1 and BO-2 panels over nine years (Table 2) showed that RRII 429 recorded the highest yield (61 g tree^{-1} tap^{-1}) which was significantly superior to that of RRIM 600 (39 g tree^{-1} tap^{-1}) followed by RRII 417 (54 g tree^{-1} tap^{-1}) and RRII 422 (51 g tree^{-1} tap^{-1}). The pre-winter yield contribution of RRII 429 was however similar to RRIM 600. Highest dry rubber content was found in RRII 417 (33%) while it was 30.8 per cent in RRIM 600.

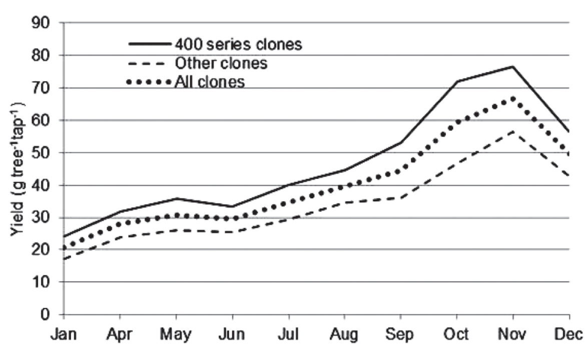

Fig. 1. Monthly yield variation in different groups of clones

In order to understand the monthly distribution of yield, the yield of ten clones were divided into three groups *viz.* RRII 400 series clones, other clones and all clones (average of all ten clones). From May till December, there was a gradual increase in yield in all the groups with an appreciable yield increase during pre-winter (October to December) period (Fig.1). However, the yield of RRII 400 series clones was much higher than the other groups especially during pre-winter period indicating that clones of this group were well adapted with the prevailing winter temperature.

A simple linear correlation between yield and growth parameters in different clones is given in Table 3. The correlations were split into two categories: (1) RRII 400 series and (2) all the 10 clones. In the RRII 400 series category, a significant correlation was observed between yield and girth at opening, girth at 14th year, clear bole volume, biomass and girth increment during immature phase.

Table 3. Simple correlation between yield and growth variables

Categories	Sample size	Girth at 14th year	Girth at opening	Clear bole volume	Biomass	Girth increment at immature phase	Girth increment at mature phase
Among five 400 series clones	30	0.852**	0.624**	0.765**	0.844**	0.507**	0.266
Among all the 10 clones	60	0.36**	0.44**	-0.10	0.37**	0.45**	0.37**

** Significant at 1 per cent level

Table 4. Estimated components of variance for different traits

Characters	Mean square	Error variance	Genotypic variance	Phenotypic variance	Genotypic coefficient of variance (%)	Phenotypic coefficient of variance (%)	Clonal repeatability	Broadsense heritability (%)
Yield (g tree^{-1}tap^{-1})	231.30	9.42	22.19	31.61	12.57	15.00	0.70	41.25
DRC (%)	2.53	0.51	0.02	0.72	1.43	2.7	0.28	22.03
Girth at opening (cm tree^{-1})	51.27	16.63	3.46	20.10	4.05	9.76	0.17	14.70
Girth (cm tree^{-1})	30.05	4.20	2.59	6.78	2.85	4.61	0.38	27.60
Clear bole volume (m^3 tree^{-1})	1.15	0.39	0.08	0.46	10.84	26.68	0.16	14.16
Biomass (kg tree^{-1})	2959.77	430.12	252.96	683.15	13.25	8.06	0.37	27.02

In the second set, however, clear bole volume was not correlated with rubber yield. This indicated that RRII 400 series clones in particular were adapted to the agro-climate of the region and rubber yield in the new clones increased concomitantly with growth, biomass and timber volume. Components of variance *viz.* genotypic and phenotypic variance, clonal repeatability over seasons and broad sense heritability were calculated (Table 4). The clonal repeatability for yield was found to be 0.7 and broad sense heritability was 41.25 indicating better stability and heritability of the trait over seasons. With respect to growth traits, the clonal repeatability estimates and broad sense heritability ranged from 0.16 to 0.38 and 14.7 to 27.6 respectively suggesting low response that could result from selection. Among the traits studied rubber yield is the one that can be improved by selection, as also reported earlier (Mydin and Mercykutty, 2007).

The influence of genotype x environment interactions in *Hevea* has been emphasized (Meenattoor *et al.*, 2000). Growers would prefer to use a high yielding cultivar that will perform consistently from year to year. Hence the identification of superior varieties should not only depend on the mean yield per se but also on the stability for yield. A genotype is considered stable if, in a given location, its yield remains more or less constant over the years (Prabhakaran and Jain, 1994). Kang (1993) proposed a method to combine yield and stability into a single criterion. In the present study, ranking of clones simultaneously

Table 5. Simultaneous selection for yield and stability.

Clone	Mean yld	Yld rank	Adjto Y	Adjusted Y	Stability variance	Stability rating	YS	F
RRII 429	65.9	10	3	13	25.16	-4	9	2.36 *
RRII 417	58.4	9	3	12	34.57	-8	4	3.25 **
RRII 422	55.4	8	2	10	30.75	-8	2	2.89 **
RRII 430	51.9	7	1	8	19.70	0	8	1.85
RRII 105	46.3	6	-1	5	6.39	0	5	0.60
RRIM 600	39.6	5	-2	3	8.88	0	3	0.83
RRII 414	39.0	4	-2	2	6.99	0	2	0.66
RRII 203	38.5	3	-2	1	40.54	-8	-7	3.81 **
PB 217	37.1	2	-2	0	8.80	0	0	0.83
RRII 176	34.7	1	-3	-2	19.17	0	-2	1.80
G mean	46.7						2.4	

* Significant at 5 per cent level; ** Significant at 1 per cent level

selected for yield and stability are given in Table 5. Among the high yielders RRII 430 followed by RRII 429 combined high yield and stability in the yield performance over the years. The very high stability in yield performance was recorded by RRII 430. RRII 417 and RRII 422 though high yielding were less consistent in their yield performance over years. The suitability of RRII 429, RRII 417 and RRII 422 to non-traditional rubber growing areas has been reported (Meenakumari *et al.*, 2011) based on early yield performance. Long term performance of these clones reconfirms the potentiality of RRII 429 as the most suitable clone for the sub Himalayan West Bengal. RRII 417 and RRII 430 could be considered as the other top ranking clones. The cold susceptibility of RRII 422 (Meti *et al.*, 2003) makes it less congenial for cultivation in the region.

Conclusion

This study on performance of new generation clones in Sub-Himalayan West-Bengal revealed that RRII 429 as the best clone in the region in terms of girth, biomass and yield. Therefore, RRII 429 followed by RRII 417 and RRII 430 would be the preferred clones for the region. Heritability estimates showed prospects of improvement in rubber yield by selection.

Acknowledgement

The authors are thankful to Dr. James Jacob, Director of Research for the encouragement in conducting the experiment. The help of all the scientists associated at the initial phase of trial and the field staffs is also acknowledged for this study.

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